59th Medical Wing Science and Technology

JBSA-Lackland, Texas 78236-5415

En route Care Research Center

SCIENTIFIC AND TECHNICAL REPORT

Critical Care Air Transport Team Evacuation of Medical Patients without Traumatic Injury

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November 2018

NOTICE AND SIGNATURE PAGE

The views expressed are those of the authors and do not reflect the official views of the Department of Defense or its Components.

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
11/15/2018	Closeout	01/01/2014 – 11/01/2018

4. TITLE AND SUBTITLE
Critical Care Air Transport Team Evacuation of Medical Patients without Traumatic Injury

5a. CONTRACT NUMBER
N62645-14-C-4041

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER
AC14ECO2

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
59th MDW/ST
1632 Nellis St
JBSA Lackland AFB, TX 78236

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
59th MDW and Air Force Medical Service / AMC

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution A. Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Background: Air Force Critical Care Air Transport Teams (CCATTs) provide fixed-wing aeromedical evacuation for combat casualties. Multiple studies have evaluated CCATT trauma patients; however, nearly 50% of patients medically evacuated from combat theaters are for nontraumatic medical illnesses to include stroke, myocardial infarctions, overdose, and pulmonary emboli. Published data are limited regarding illness types, in-flight procedures, and adverse events. **Objective:** The objective of our study was to characterize patients with nontraumatic medical illnesses transferred via CCATT to include a description of in-flight procedures and events. **Study Design:** We performed a retrospective review of CCATT medical records of patients with nontraumatic medical illnesses transported via CCATT from theater of operations to Landstuhl Regional Medical Center between January 2007 and April 2015. We abstracted data from CCATT records to include demographics, description of current illness, vital signs, labs, in-flight procedures and medications, and in-flight adverse events. Following descriptive analysis, comparative tests were performed based on service status of patients and primary diagnoses. **Results:** We reviewed 672 records of critically-ill medical patients transported via CCATT, most of whom were male (90%, n = 606). Approximately 56% of the patients were U.S. active duty members; the remainder included U.S. contractors and civilians, and foreign citizens or unknown. The three categories (active duty, contractor/civilian, foreign/unknown) significantly differed from one another in age. Over half of the patients received a primary or secondary cardiac diagnosis. The most common in-flight procedures and medications included supplementary oxygenation, anticoagulant/antiplatelet medications, analgesics, and ventilation. Up to 20% of patients required continuous medication infusions other than analgesics. Patients most frequently experienced in-flight complications related to their primary diagnoses. **Conclusions:** Fifty-six percent (672) of 1,209 CCATT records that were queried were of patients with nontraumatic medical conditions. The most common primary diagnoses of CCATT medical patients were cardiac, pulmonary, and neurological in etiology. Mechanical ventilation and continuous medication infusions were required in approximately 20% of patients. The data provided by this study may assist in guiding future CCATT training requirements and resource allocation, as well as clinical practice guideline development.

15. SUBJECT TERMS

Non-Trauma, Aeromedical Evacuation, Critical Care, En route Care, DNBI

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Joseph K. Maddry, MD
U	U	U	SAR		19b. TELEPHONE NUMBER *(Include area code)* 210-539-4403

Standard Form 298 (Rev. 8/98)

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1.0 SUMMARY

Critical Care Air Transport Team Evacuation of Medical Patients without Traumatic Injury

Gaps Addressed: 2015 ICL: AFMS (AMC) 25 - Epidemiology and Clinical Evaluation Outcomes; AFMS 61 (AMC) Clinical and Functional Outcomes of Patient Movement

2016 AE RDD: CCA – Clinical En Route Care - 2. Epidemiology and Clinical Evaluation Outcomes; 5. Clinical/Functional Outcomes of Patient Movement

Modified Abstract

Background: Air Force Critical Care Air Transport Teams (CCATTs) provide fixed-wing aeromedical evacuation for combat casualties. Multiple studies have evaluated CCATT trauma patients; however, nearly 50% of patients medically evacuated from combat theaters are for nontraumatic medical illnesses. In 2012 and 2013, the Armed Forces Health Surveillance Center reported that more than 50,000 service members serving in Operation Iraqi Freedom/Operation New Dawn and more than 20,000 serving in Operation Enduring Freedom (OEF) necessitated medical evacuations from medical treatment facilities to a hospital out of theater. In these reports of both critical and noncritical medical evacuations, there were almost five times more medical evacuations secondary to disease and nonbattle injury (DNBI) compared to battle-related injuries.

Objective: The objective of our study was to characterize patients with nontraumatic medical illnesses transferred via CCATT to include a description of in-flight procedures and events.

Methods: We performed a retrospective review of CCATT medical records of patients with nontraumatic medical illnesses transported to Landstuhl Regional Medical Center from the combat theater between January 2007 and April 2015. Following descriptive analysis, comparative tests were performed based on service status of patients and primary diagnoses.

Results:

- 672 (52%) of 1209 patients transported by CCATT to LRMC during the study period were medical patients without traumatic injury.
- 376 (56%) were US active duty, 257 (38%) were US contractor/Civilian and 39 (6%) were foreign/unknown.
- The active duty mean age was 34 and the contractor/civilian mean age was 51, both groups were older than the mean age of 27 for trauma patients.
- The most prevalent diagnosis type was cardiac (52%), followed by neurologic (16%) and pulmonary (13%).

- Non-active duty patients were more likely to have a cardiac diagnosis, while active duty were more likely to have a pulmonary diagnosis. The most common diagnoses in each system include:
    - Cardiac – myocardial infarction, chest pain, atrial fibrillation
    - Pulmonary – pneumonia, pulmonary embolism, respiratory failure
    - Neurologic – seizure disorder, nontraumatic cerebral hemorrhage, stroke
- In-flight care requirements included: supplemental oxygen, anticoagulant/antiplatelet medications, analgesics, sedatives, mechanical ventilation, blood products, proton pump inhibitors, cardiac medications, and antihypertensives (listed in order of frequency).
- In-flight events included: Cardiac (changes in VS), pain, and fever.

Conclusions: The most common primary diagnoses of CCATT medical patients are cardiac, pulmonary, and neurological in etiology. Mechanical ventilation and continuous medication infusions were required in approximately 20% of patients.

Evidence Based Recommendations:

- Military planners should anticipate patients with medical diagnosis will make up a significant proportion of both critical and non-critical medical evacuations and plan accordingly.
- Given the advancing age of personnel supporting military operations (Active Duty, Reserves, National Guard, and contractors) and advances in the management of infectious disease, military planners should anticipate cardiac, pulmonary, and neurologic diseases in greater frequency than during prior conflicts where infectious disease predominated.
- Prescreening of personnel (to include contractors) for cardiac, pulmonary, and neurologic disease may decrease CCATT evacuation requirements.
- CCATT training should include the management of patients with cardiac, pulmonary, and neurologic critical illnesses.
- In environments where rapid aeromedical evacuation is not available, medical personnel should have sufficient training and equipment to treat cardiac, pulmonary, and neurologic disease.

2.0 INTRODUCTION

Although most en route care studies focus on patients with combat-related traumatic injuries, between 30 and 50% of Critical Care Air Transport Team (CCATT) evacuations are of patients with medical (nontraumatic) critical illnesses (e.g., cerebrovascular accident, myocardial infarction [MI], overdose, and sepsis).(1,2) A CCATT is an Air Force team consisting of a critical care physician, a critical care nurse, and a respiratory therapist that are capable of providing care for up to six patients (or up to three ventilated patients) during prolonged aeromedical evacuation.(3) In 2012 and 2013, the Armed Forces Health Surveillance Center reported that more than 50,000 service members serving in Operation Iraqi Freedom/Operation New Dawn and more than 20,000 serving in Operation Enduring Freedom (OEF) required medical evacuations from theater medical treatment facilities to a hospital out of theater.(4,5) In these reports of both critical and noncritical medical evacuations, there were almost five times more medical evacuations secondary to disease and nonbattle injury (DNBI) compared to battle-related injuries. Historically, noncombat medical illnesses have required greater hospital resources and subsequent higher lost person days; conferring a greater impact on operational capability. (6–8) The disease processes of critically ill patients can progress suddenly which may require expeditious transport to higher level care facilities. CCATT addresses the needs of the critically ill patients by providing advanced medical care during transport. (3)

Evidence gathered from the field during wartime is a key component to optimizing health care delivery in a combat setting. We know that extensive medical resources and medical provider training are necessary to appropriately care for critically ill medical patients in theater. (8–10) However, to date, there remains a significant gap in the literature describing the critical care needs of complex medical patients during aeromedical evacuation. As part of an evolving medical system, military medicine must continuously strive for optimal medical care delivery in theater. Not only are published studies focusing on the aeromedical transport of medical patients limited; studies that have evaluated DNBI admitted to medical facilities in the combat theater have not focused on critically ill medical patients nor included the patients aeromedical evacuation from theater. (9,10) Although some studies have provided epidemiological data regarding DNBI aeromedical transports and CCATT missions, these studies did not evaluate the patient's clinical course or therapies provided during en route care.(1,2,11)

Mason et al (12) conducted a prospective study of 133 patients transported by CCATT from Balad Air Base in Iraq to Landstuhl Regional Medical Center (LRMC) over a 1-year period. Forty-six (35%) were medical patients, of which 68% had a cardiac diagnosis. The study described and compared in-flight devices, treatments, and complications. A retrospective chart review of 656 patients transported by CCATT over a 16-month period during Operation Iraqi Freedom and OEF, made similar comparisons and had similar results.(13) In this group, 231 (35%) were medical patients and 55% had a cardiac diagnosis. These studies represent smaller groups over shorter time periods; however, the results indicate a need to fully understand the impact of the transport of medical patients out of theater on military resource utilization.

The objective of this study was to characterize critically ill medical patients evacuated via CCATT to include type of illness, in-flight procedures, and adverse events. The data provided by this retrospective chart review may support the design of evidence-based clinical practice guidelines (CPGs) to be used when transferring nontraumatic critically ill patients and may be used as an evidence-based approach to improve clinical outcomes.

3.0 METHODS

3.1 Study Design and Setting

This retrospective study was approved by the U.S. Army Military Research and Materiel Command Institutional Review Board. Abstractors were trained to interpret CCATT medical records and used standardized tools to determine relevant medical events of interest. We ensured accuracy and consistency of data collection through routine training, quality assurance, and quality control assessments. (14)

3.2 Selection of Participants

We initially reviewed the CCATT records of 1,209 patients transported from any theater of operations from January 2007 to April 2015. For this study, we included only 672 patients without traumatic injuries taken to LRMC.

3.3 Measurements

Using a study-specific electronic database (Microsoft Excel 2010; Microsoft Corporation, Redmond, Washington) with predefined fields, we abstracted data from CCATT records to include demographics, description of current illness, vital signs, labs, in-flight procedures and medications, and in-flight adverse events (see Table I for event definitions).

Table1: Definitions of In-Flight Events

Event Type	Definition
Pain	Increase in rate or dose of existing analgesia Start of new analgesia A verbalized complaint of pain As determined by CCATT provider to include: Headache, chest, abdominal, back, hip, leg/knee, arm/shoulder, muscle pain
Respiratory	$SpO_2 \leq 90\%$ FiO_2 increase >10% O_2 L/min increase >4 ≥5 increase in PEEP
Cardiac	SBP ≤90 or ≥180 or 20% change from baseline MAP ≤65 or ≥120 or 20% change from baseline CVP change from baseline of 5 HR <60 bpm or >120 bpm or 20% change from baseline
Neurological	As determined by CCATT provider to include: Agitation, seizures, change in mental status, motor, cognitive, or sensory ability
Renal/urinary	As determined by CCATT provider to include: Oliguria (low urine output), dark urine, renal calculus
Temperature	Fever (body temperature ≥ 100.5 F or 38 C) Hypothermia (body temperature < 95 F or 35 C)
Equipment failure	As determined by CCATT provider to include: Propaq failure, battery failure, ventilator failure
Abnormal lab	Glucose (<70 or >105) Potassium (<3.5 or >5) Sodium (<136 or >145) PTT (>35)

3.4 Outcomes – Outcome data were not available for this patient population.

3.5 Analysis

We conducted statistical analysis using JMP, version 10 (SAS Institute; Cary, North Carolina). Initial descriptive analyses were performed, followed by comparative tests such as analysis of variance (ANOVA) for continuous variables and χ 2(or Fisher exact test when appropriate) for categorical variables. For analysis, patients were categorized by service status (active duty, contractor/civilian, or foreign/unknown) and by primary diagnosis (cardiac, pulmonary, neurological, or other). The "other" primary diagnosis was inclusive of gastrointestinal, renal, hematological, endocrine, vascular, hepatic, immune, orthopedic, and additional diagnoses not otherwise classified. The tables present overall counts and percentages, as well as counts and percentages relative to each grouping (i.e., service status for Table II, primary diagnosis for Tables III and IV). The p values in each row indicate significant group differences (at $p < 0.05$) in a χ^2 test, Fisher exact test, or ANOVA.

Table 2: Demographics

	Overall mean±SD; median [IQR] or column % [95% CI] n=672	US Active Duty mean±SD; median [IQR] or column % [95% CI] n=376	US Contractor/Civilian mean±SD; median [IQR] or column % [95% CI] n=257	Foreign/Unknown mean±SD; median [IQR] or column % [95% CI] n=39	p-value
Age	41±13; 42 [30-51]	34±11; 34 [24-43]$_a$	50±10; 51 [45-58]$_b$	40±12; 42 [31-48]$_c$	<0.0001
Gender	90% [88-93%] male	88% [85-91%] male	93% [89-96%] male	95% [82-99%] male	0.1165
Primary Diagnosis Type*					<0.0001
Cardiac	52% [48-56%]	43% [38-48%]	66% [60-71%]	41% [27-57%]	
Pulmonary	13% [10-15%]	15% [12-19%]	9% [6-14%]	8% [3-20%]	
Neurological	16% [13-19%]	18% [15-22%]	12% [8-16%]	23% [13-38%]	
Other	19% [17-23%]	23% [19-28%]	13% [10-18%]	28% [17-44%]	
Number of Diagnoses					0.4331
One	92% [89-93%]	93% [89-95%]	91% [87-94%]	85% [70-93%]	
Two or more	8% [6-10%]	7% [5-10%]	9% [6-13%]	15% [7-30%]	
Unknown	<1% [0-1%]	<1% [0-2%]	<1% [0-2%]	0% [0-0%]	

Note. "Other" includes gastrointestinal (n=34), renal (n=22), hematological (n=17), endocrine (n=13), vascular (n=12), hepatic (n=5), immune (n=4), orthopedic (n=4), etc.

Column percentages are given. P-values are for chi-square (or Fisher's exact) test or one-way ANOVA. Different subscripts (a, b, c) represent significant mean differences among groups in a one-way ANOVA.

4.0 RESULTS

4.1 Characteristics of Study Subjects

We reviewed 672 records of medical patients (those without traumatic injuries) transported via CCATT (mean flight time: 7.5 hours, SD ± 2.29), most of whom were male (90%, n = 606). Approximately 56% of the patients were U.S. active duty members and the remaining 44% included U.S. contractors and civilians, and foreign citizens or unknown. The three categories (active duty, contractor/civilian, foreign/unknown) significantly differed from one another in age.

4.2 Main Results

Active duty members were more likely to receive primary pulmonary diagnoses and “other” diagnoses, U.S. contractors and civilians were more likely to receive cardiac diagnoses, and foreign patients received more neurological and “other” diagnoses (Table II). Most patients (92%) received only one diagnosis, with 8% receiving two or more. Cardiac was the most prevalent type of secondary diagnosis (n = 14), followed by pulmonary (n = 11), vascular (n = 8), and renal (n = 5). For patients with a primary cardiac diagnosis, secondary pulmonary diagnoses (n = 7) were the most prevalent and vice versa (i.e., six pulmonary patients had a secondary cardiac diagnosis). Neurological patients most frequently experienced a secondary vascular diagnosis (n = 5); patients with an “other” diagnosis experienced a variety of secondary conditions (e.g., cardiac, hematological, pulmonary).

Over half of the patients received either a primary or secondary cardiac diagnosis (n = 362), with the most frequent diagnoses being MI (n = 138), chest pain/angina pectoris (n = 93), and atrial fibrillation (n = 27). Pulmonary diagnoses were given to 95 patients, including pneumonia (n = 38), pulmonary embolism (n = 20), and respiratory failure (n = 8). Of the neurological diagnoses (n = 109), seizure disorder (n = 19), nontraumatic intracranial hemorrhage (n = 14), and stroke (n = 10) were the most prevalent. Other diagnoses included renal failure (n = 17), pancreatitis (n = 10), and diabetic ketoacidosis (n = 9).

Overall, the most common in-flight procedures and medications included continued supplementary oxygenation, anticoagulant/antiplatelet medications, analgesics, and ongoing ventilation (Table III). Patients with a primary pulmonary diagnosis were more likely to begin transport on a ventilator and be given analgesics, sedatives, and paralytics en route, whereas cardiac patients were more likely to receive supplementary oxygenation and cardiovascular and hemodynamic drugs. Those with a primary diagnosis in the “other” category were more likely to receive blood products, analgesics, proton-pump inhibitors, and insulin in flight.

Table 3: In-Flight Procedures and Medications by Primary Diagnosis Type

	Overall column % [95% CI] n=672	Cardiac column % [95% CI] n=348	Pulmonary column % [95% CI] n=84	Neurological column % [95% CI] n=107	Other column % [95% CI] n=133	p-value
Ongoing ventilation	21% [18-24%]	5% [3-8%]	71% [44-65%]	36% [28-46%]	28% [21-36%]	<0.0001
Trach.	<1% [0-1%]	<1% [0-1%]	1% [0-6%]	0% [0-0%]	0% [0-0%]	NA
Trach. without ventilation	<1% [0-1%]	0% [0-0%]	1% [0-6%]	0% [0-0%]	0% [0-0%]	NA
Other O2	62% [58-65%]	76% [71-80%]	40% [31-51%]	49% [39-58%]	50% [41-58%]	<0.0001
Blood products	1% [1-3%]	0% [0-0%]	0% [0-0%]	2% [1-7%]	6% [3-11%]	<0.0001
Paralytics	4% [3-6%]	1% [0-3%]	13% [7-22%]	4% [1-9%]	5% [3-10%]	<0.0001
Analgesics	30% [26-33%]	21% [17-25%]	48% [37-58%]	30% [22-39%]	41% [33-49%]	<0.0001
Sedatives	24% [21-27%]	11% [8-15%]	51% [41-62%]	36% [28-46%]	29% [22-38%]	<0.0001
Cardiac medications	20% [17-23%]	28% [23-33%]	14% [8-23%]	9% [5-16%]	11% [6-17%]	<0.0001
Antiarrhythmics (IV)	4% [3-6%]	7% [5-10%]	0% [0-0%]	2% [1-7%]	2% [1-6%]	<0.0001
Vasopressors (IV)	5% [4-7%]	3% [1-5%]	10% [5-18%]	6% [3-12%]	8% [4-13%]	0.0194
Vasodilators (IV)	11% [9-13%]	19% [15-23%]	2% [1-8%]	2% [1-7%]	2% [0-5%]	<0.0001
Nitroglycerin (IV)	10% [8-12%]	18% [15-23%]	1% [0-6%]	0% [0-0%]	0% [0-0%]	<0.0001
Nitroglycerin (all)	18% [15-21%]	34% [29-39%]	1% [0-6%]	1% [0-5%]	0% [0-0%]	<0.0001
Anti-coagulant/anti-platelets	46% [42-49%]	59% [54-64%]	48% [37-58%]	26% [19-35%]	25% [18-33%]	<0.0001
Statins	12% [10-15%]	20% [16-25%]	0% [0-0%]	8% [4-15%]	2% [0-5%]	<0.0001
Anti-hypertensives (oral)	20% [18-24%]	35% [30-40%]	4% [1-10%]	7% [3-13%]	5% [3-10%]	<0.0001

	Overall column % [95% CI] n=672	Cardiac column % [95% CI] n=348	Pulmonary column % [95% CI] n=84	Neurological column % [95% CI] n=107	Other column % [95% CI] n=133	p-value
PPI	21% [18-24%]	13% [11-18%]	29% [20-39%]	22% [15-30%]	32% [25-41%]	<0.0001
Insulin	3% [2-5%]	1% [0-3%]	1% [0-6%]	5% [2-10%]	9% [5-15%]	<0.0001
KCl/CaCl2/Mg	10% [8-12%]	8% [6-11%]	12% [7-21%]	7% [3-13%]	14% [9-21%]	0.1097

Note. IV, intravenous; PPI, proton pump inhibitor; KCl, potassium chloride; CaCl, calcium chloride; Mg, magnesium. "Other O2" does not include room air. Patients may receive multiple medications/procedures. Column percentages are given. P-values are for chi-square (or Fisher's exact) test. Rows marked NA did not have sufficient data for analysis.

Frequencies of in-flight events are listed in Table IV. Patients most frequently experienced complications related to their primary diagnoses (e.g., cardiac patients had cardiac events). However, cardiac patients were also more likely to report pain (particularly chest pain and headaches) during transport and neurological patients frequently had cardiac events and equipment failures in flight. Pulmonary patients experienced more temperature-related events in addition to respiratory complications. Patients with an "other" primary diagnosis were more likely to experience respiratory events, renal/urinary issues, temperature events, and abnormal lab results during transport.

Table 4: In-Flight Events by Primary Diagnosis Type

	Overall column % [95% CI] n=672	Cardiac column % [95% CI] n=348	Pulmonary column % [95% CI] n=84	Neurological column % [95% CI] n=107	Other column % [95% CI] n=133	p-value
Pain	20% [17-23%]	24% [19-28%]	14% [8-23%]	7% [4-14%]	23% [17-31%]	0.0011
Chest	9% [7-11%]	14% [11-18%]	8% [4-16%]	1% [0-5%]	<1% [0-4%]	<0.0001
Headache	3% [2-5%]	4% [3-7%]	0% [0-0%]	5% [1-9%]	0% [0-0%]	0.0158
Abdominal	2% [1-3%]	<1% [0-2%]	0% [0-0%]	0% [0-0%]	9% [5-15%]	<0.0001
Respiratory	9% [7-11%]	6% [4-9%]	20% [10-26%]	7% [2-10%]	14% [9-21%]	0.0001
FiO_2 ↑>10%	4% [3-6%]	1% [1-3%]	13% [7-22%]	5% [2-10%]	7% [4-12%]	<0.0001
$SpO_2 \leq 90\%$	2% [1-4%]	1% [1-3%]	4% [1-10%]	2% [1-7%]	5% [2-9%]	0.2066
O_2 L/min ↑>4	2% [1-3%]	3% [1-5%]	5% [2-12%]	0% [0-0%]	0% [0-0%]	0.0286

	Overall column % [95% CI] n=672	Cardiac column % [95% CI] n=348	Pulmonary column % [95% CI] n=84	Neurological column % [95% CI] n=107	Other column % [95% CI] n=133	p-value
Cardiac	71% [67-74%]	74% [69-78%]	60% [49-69%]	74% [65-81%]	66% [58-74%]	0.0364
HR	54% [50-57%]	62% [57-67%]	36% [26-46%]	54% [45-63%]	43% [35-51%]	<0.0001
MAP	31% [28-35%]	28% [23-33%]	31% [22-41%]	37% [29-47%]	36% [28-45%]	0.1386
SBP	26% [23-30%]	24% [19-28%]	33% [24-44%]	27% [20-36%]	29% [22-38%]	0.2488
Neurological	4% [3-5%]	1% [0-3%]	1% [0-6%]	15% [9-23%]	4% [2-8%]	<0.0001
Agitation	1% [1-2%]	0% [0-0%]	1% [0-6%]	3% [1-8%]	3% [1-7%]	0.0162
Renal/urinary	4% [3-6%]	1% [1-3%]	5% [3-15%]	7% [3-13%]	8% [4-13%]	0.0058
Oliguria	3% [2-5%]	1% [1-3%]	4% [1-10%]	6% [3-12%]	5% [3-10%]	0.1416
Dark urine	1% [1-2%]	0% [0-0%]	5% [3-13%]	1% [0-5%]	<1% [0-4%]	0.0117
Temperature	11% [9-14%]	4% [2-7%]	25% [17-35%]	15% [9-23%]	20% [14-27%]	<0.0001
Fever	10% [8-12%]	3% [2-5%]	24% [16-34%]	11% [7-19%]	18% [12-25%]	<0.0001
Hypothermia	1% [1-3%]	1% [0-3%]	1% [0-6%]	4% [1-9%]	2% [0-5%]	0.3122
Equip. failure	2% [1-3%]	1% [0-2%]	2% [1-8%]	5% [2-10%]	3% [1-7%]	0.0365
Abnormal lab	16% [13-19%]	6% [4-9%]	21% [14-31%]	23% [16-32%]	34% [26-42%]	<0.0001
Sodium	10% [8-12%]	3% [2-6%]	11% [6-19%]	17% [11-25%]	20% [14-28%]	<0.0001
Potassium	7% [5-9%]	2% [1-4%]	8% [4-16%]	5% [2-10%]	18% [12-25%]	<0.0001
Glucose	5% [3-6%]	1% [1-3%]	5% [2-12%]	10% [6-17%]	8% [5-14%]	0.0002

Note. Column percentages are given. Most common events are listed. Events with overall count <5 are excluded from the list. Patients may experience multiple events. Equipment failures include Propaq monitor (n=3), battery (n=3), power cord/cable (n=2), arterial line (n=1), peripheral intravenous (IV) device infiltration (n=1), portable therapeutic liquid oxygen (PT-LOX) (n=1), temperature probe (n=1), and i-Stat blood analysis system (n=1). P-values are for chi-square (or Fisher's exact) test.

5.0 DISCUSSION

Generally speaking, critically-ill medical patients require different interventions and medications than trauma patients and challenge the provider in a unique way. In this study, we found the majority of critical care transport medical patients suffered from cardiac, pulmonary, and neurological illnesses. To our knowledge, this study is the most comprehensive report from the actual CCATT and evacuation medical records describing the frequency and types of in-flight procedures and medications administered (Table III) en route. The majority of these patients required airway and/or oxygen support and administration of multiple classifications of medications, including cardiac medication infusions and other vasoactive medications to address their specific medical conditions.

The most significant proportion of patients in this study had a cardiac complaint that was subsequently diagnosed as MI. The treatment for MI presents a unique challenge since the lack of a cardiac catheterization laboratory in Afghanistan necessitates pharmacological intervention with intravenous thrombolytics. Additionally, over a quarter of the cardiac patients were placed on a continuous infusion of cardiac medications such as antiarrhythmics, vasopressors, or vasodilators. Given the frequent monitoring and dosing adjustments required of vasoactive infusions and antiarrhythmics, cardiac patients may place a significant workload on CCATTs, potentially impacting the number of patients they are able to safely provide care for. Consequently, CCATTs ensure a high level of expertise in the use of these intravenous medications.

Twenty-one percent (20/95) of patients with a pulmonary diagnosis in our study had pulmonary embolism, which is more than twice the rate reported in a previous study or in the traumatically injured CCATT patients. (1) Although the risk of pulmonary embolus increases with age, this diagnosis was more common among the younger military population when compared to contractors in this study. Prolonged aeronautical transport and improved diagnostic capabilities may account for the high frequency of pulmonary emboli in this study.

During World War I, World War II, and the Korean War, overall noncombat casualties consisted primarily of infectious diseases. (4,14–16) In our study of evacuated patients, pneumonia was the most common infectious disease but only accounted for 6% of the total patients. The decline in infectious disease is likely the result of improved public health practices, malaria prophylaxis, and the use of modern antibiotics. Conversely, the increased percentage of cardiac, pulmonary, and neurological symptoms is likely the result of the increased age of deployed active duty, reservist, and National Guard personnel as well as increased reliance on contractors to support military operations.

A study of inpatients at a British hospital during OEF identified infectious diseases, diseases of the circulatory system, and diseases of the respiratory systems as the most common causes of admission. (9) Previous studies have found that the majority of noncombat–related aeromedical evacuations out of Iraq and Afghanistan were associated with musculoskeletal, gastrointestinal, and neurological pathology; cardiac and pulmonary complaints accounted for less than 5% of patients. (11) The difference between these studies and our study is reflective of patients with perceived higher acuity or a documented risk of clinical deterioration while being transferred via CCATT.

Most published CCATT research focuses on aeromedically transported trauma patients. Since medical diseases account for a substantial proportion of CCATT evacuations, our study focused on evaluating a unique aspect of critical care evacuation. (12,13) The Air Force's CCATT is uniquely tasked in providing medical intensive care to patients during prolonged transportation. In spite of the acuity of trauma transports (often post-surgery polytrauma with extremity amputations, head injury, and/or burns) and the specialized care rendered, incidence rates of in-flight events are low (Table V). In comparison, nontrauma transports require a more specialized and labor-intensive level of care (Table III) and experience higher incidences of in-flight events (Table IV).

Findings within our study highlight the necessarily medical supplies, CPGs, and training needed to ensure a high-quality continuum of care for medical patients during CCATT missions. More specifically, our findings suggest CCATT training and CPGs should include the management of cardiac, pulmonary, and neurological medical illness to include ventilator management in pulmonary patients and continuous vasoactive and antidysrhythmic medications in older cardiovascular patients.

Future studies are essential for evaluation of the impact of CCATT care on medical patients' clinical outcomes. This type of outcomes research would enable researchers, educators, and logisticians to further determine what training and equipment are fundamental for minimizing morbidity and mortality of medical CCATT patients. To date, outcomes research has been limited due to the lack of a consolidated medical database for medical patients. Although the Department of Defense Trauma Registry (DoDTR) has provided an essential database from which to extract 30-day outcomes for trauma patients, no such equivalent exists for nontrauma outcomes. Data collection is further complicated by the fact that most contractors are transferred to the civilian health care system following departure from the theater of operations. Prospective studies should further address the impact of care provided during aeromedical evacuation on patient outcomes. Additional research efforts may also target those methods that minimize medical illnesses which require aeromedical evacuation. Assessment of prevention measures for conditions such as deep vein thrombosis and minimizing deployments of contractors at risk for significant cardiac events may also help reduce DNBI evacuations.

Limitations

Retrospective studies such as these are often limited as a result of incomplete or missing data and multi-abstractor subjectivity. To minimize these limitations, we evaluated 672 medical records and provided chart abstraction and substantive abstractor training. Furthermore, we implemented quality review procedures during the collection of our data. (12) We do not have access to outcome data, thus limiting the ability to compare effects of interventions and other group differences. Despite the inherent limitations, this study is the first to describe the en route CCATT care administered to critically ill medical patients. This information can be used to guide resource allocation, pre-deployment training, and the development of CPGs.

Conclusion

The most common primary diagnoses of CCATT medical patients are cardiac, pulmonary, and neurological in etiology. Mechanical ventilation and continuous medication infusions were required in approximately 20% of patients. Information obtained in this study may assist in guiding future CCATT training requirements and resource allocation.

6.0 REFERENCES

1. Bridges E, Evers K: Wartime critical care air transport. Mil Med 2009;174(4): 370–5.

2. Hauret KG, Taylor BJ, Clemmons NS, Block SR, Jones BH: Frequency and causes of nonbattle injuries air evacuated from Operations Iraqi Freedom and Enduring Freedom, U.S. Army, 2001-2006. Am J Prev Med 2010; 38(1 Suppl): S94–107.

3. Ingalls N, Zonies D, Bailey JA, et al: A review of the first 10 years of critical care aeromedical transport during operation Iraqi freedom and operation enduring freedom: the importance of evacuation timing. JAMA Surg 2014; 149(8): 807–13.

4. Armed Forces Health Surveillance Center (AFHSC): Medical evacuations from Operation Iraqi Freedom/Operation New Dawn, active and reserve components, U.S. Armed Forces, 2003–2011. MSMR 2012;19(2): 18–21.

5. Armed Forces Health Surveillance Center (AFHSC): Medical evacuations from Afghanistan during Operation Enduring Freedom, active and reserve components, U.S. Armed Forces, 7 October 2001–31 December 2012. MSMR 2013; 20(6): 2–8.

6. Withers BG, Erickson RL, Petruccelli BP, Hanson RK, Kadlec RP: Preventing disease and non-battle injury in deployed units. Mil Med 1994; 159(1): 39–43.

7. Blood CG, Jolly R: Comparisons of disease and nonbattle injury incidence across various military operations. Mil Med 1995; 160(5):258–63.

8. Sanders JW, Putnam SD, Frankart C, et al: Impact of illness and non-combat injury during Operations Iraqi Freedom and Enduring Freedom (Afghanistan). Am J Trop Med Hyg 2005;73(4): 713–9.

9. Cox AT, Lentaigne J, White S, et al: A 2-year review of the general internal medicine admissions to the British Role 3 Hospital in Camp Bastion, Afghanistan. J R Army Med Corps 2016; 162(1): 56–62.

10. Cox AT, D Linton T, Bailey K, et al: An evaluation of the burden placed on the General Internal Medicine team at the Role 3 Hospital in Camp Bastion by UK Armed Forces personnel presenting with symptoms resulting from previously identified disease. J R Army Med Corps 2016; 162(1): 18–22.

11. Cohen SP, Brown C, Kurihara C, Plunkett A, Nguyen C, Strassels SA: Diagnoses and factors associated with medical evacuation and return to duty among nonmilitary personnel participating in military operations in Iraq and Afghanistan. CMAJ 2011; 183(5): E289–95.

12. Mason PE, Eadie JS, Holder AD: Prospective observational study of United States (US) AirForce Critical Care Air Transport Team operations in Iraq. J Emerg Med 2011; 41(1): 8–13.

13. Lairet J, King J, Vojta L, Beninati W: Short-term outcomes of US Air Force Critical Care Air Transport Team (CCATT) patients evacuated from a combat setting. Prehosp Emerg Care 2013; 17(4);486–90.

14. Gilbert EH, Lowenstein SR, Koziol-McLain J, Barta DC, Steiner J: Chart reviews in emergency medicine research: where are the methods? Ann Emerg Med 1996; 27(3): 305–8.

15. Hoeffler DF, Melton LJ III. Changes in the distribution of Navy and Marine Corps casualties from World War I through the Vietnam conflict. Mil Med 1981; 146(11):776–9.

16. Holland BD, Long AP: Cost of non-battle injuries and diseases as compared to battle casualties. Mil Med 1955; 117(1): 46–50.

17. Renz EM, Cancio LC, Barrillo DJ, et al: Long range transport of war related burn casualties. J Trauma 2008; 64(2 Suppl): S136–44.

18. Minnick JM, Bebarta VS, Stanton M, et al: The incidence of fever in US Critical Care Air Transport Team combat trauma patients evacuated from the theater between March 2009 and March 2010. J Emerg Nurs 2013; 39(6): e101–6.

19. Mora AG, Ervin AT, Ganem VJ, Bebarta VS: Aeromedical evacuation of combat patients by military critical care air transport teams with a lower hemoglobin threshold approach is safe. J Trauma Acute Care Surg 2014; 77(5): 724–8.

20. Hamilton JA, Mora AG, Chung KK, Bebarta VS: Impact of anemia in critically ill burned casualties evacuated from combat theater via US Military Critical Care Air Transport Teams. Shock 2015; 44(Suppl 1): 50–4.

21. Mora AG, Ervin AT, Ganem VJ, Maddry JK, Bebarta VS: En route use of analgesics in nonintubated, critically ill patients transported by U.S. Air Force Critical Care Air Transport Teams. Mil Med 2016;181(5 Suppl): 145–51.e1880

APPENDIX: Publications and Presentations

A.1 Publications

Maddry JK, Arana AA, Savell SC, Reeves LK, Perez CA, Mora, AG, Bebarta VS. Critical care air transport team evacuation of medical patients without traumatic injury. Mil Med 2017;182:1874-1880.

https://www.ncbi.nlm.nih.gov/pubmed/29087856

Savell SC, Arana AA, Medellin KL, Bebarta VS, Perez CA, Reeves LK, Mora AG, Maddry JK. Descriptive analysis of cardiac patients transported by critical care air transport teams. Mil Med. Under review.

A.2 Presentations

1. Maddry JK, Russell SS, Perez CA, Paciocco J, Lear JD, Reeves LK, Mora AM. A descriptive analysis of critically ill non-trauma patients evacuated by critical care air transport teams (CCATT) out of the combat theater (2007-2015): A preliminary report. Poster. MHSRS, August 2016.

2. Medellin KL, Perez CA, Mora AG, Arana AA, Reeves LK, Savell SC, Maddry JK**,** Bebarta VS. Transport of Critically Ill Non-Trauma Patients by Critical Care Air Transport Teams (CCATT). Poster, Oral. TSNRP, April 2017

3. Medellin KL, Perez CA, Mora AG, Arana AA, Reeves LK, Savell SC, Maddry JK, Bebarta VS. Critical Care Air Transport Team (CCATT) evacuation of medical patients without traumatic injury. Poster, Oral. SURF, 2017

4. Savell S, Perez C, Reeves L, Mora A, Lear J, Paciocco J, Medellin K, Bebarta V, Maddry J. Transport of Critically Ill Non-Trauma Patients by Critical Care Air Transport Teams (CCATT). Oral. MHSRS, 2017

5. Maddry JK, Arana AA, Perez CA, Reeves LK, Mora AG, Savell SC, Medellin KL, Lear JD, Paciocco JA, Bebarta VS. Critically ill medical patients with cardiac diagnoses transported by Critical Care Air Transport Teams (CCATT). Oral. MHSRS, 2017

6. Maddry JK, Araña AA, Perez CA, Reeves LK, Mora AG, Savell SC, Medellin KL, Lear JD, Paciocco JA, Bebarta VS. Critically Ill, Medical Patients with Cardiac Diagnoses Transported by Critical Care Air Transport Teams (CCATT). Poster. GSACEP, 2018

7. Savell S, Arana A, Perez C, Reeves L, Mora A, Medellin K, Lear J, Paciocco J, Bebarta V, Maddry J. Critically ill, medical patients with cardiac diagnoses transported by Critical Care Air Transport Teams (CCATT). Oral. SURF, 2018

8. Savell S, Arana A, Perez C, Reeves L, Mora A, Medellin K, Lear J, Paciocco J, Maddry J. Critically Ill, Medical Patients with Cardiac Diagnoses Transported by Critical Care Air Transport Teams (CCATT). Poster. TSNRP, 2018

9. Maddry J. Critically Ill, Medical Patients with Cardiac Diagnoses Transported by Critical Care Air Transport Teams (CCATT). Oral. TSNRP, 2018

Appendix B Brief Reports on Subanalysis

Descriptive analysis of cardiac patients transported by critical care air transport teams

Gaps Addressed: 2015 ICL: AFMS (AMC) 25 - Epidemiology and Clinical Evaluation Outcomes; AFMS 61 (AMC) Clinical and Functional Outcomes of Patient Movement

2016 AE RDD: CCA – Clinical En Route Care - 2. Epidemiology and Clinical Evaluation Outcomes; 5. Clinical/Functional Outcomes of Patient Movement

Modified Abstract

Background: Critical Care Air Transport Teams (CCATTs) transport critically ill patients within and out of theaters of combat operations to higher levels of care. The CCATT is composed of an intensive care capable physician, nurse, and respiratory therapist. The original concept was developed with the wounded soldier in mind, to provide critical care during transport after treatment by surgical teams. With this guiding purpose, CCATT training is focused on the care of traumatically injured patients while content on emergent non-trauma conditions is limited. However, epidemiologic studies of the CCATT population reveal as many as 35% of patients have a non-trauma medical diagnosis, of which more than half are cardiac related.

The purpose of this retrospective study was to describe the epidemiology of critically ill medical patients with cardiac diagnoses evacuated from theater via CCATT.

Methods: We conducted a retrospective review of 290 medical patients with a primary cardiac diagnosis transported from any theater of operation to Landstuhl Regional Medical Center, Germany from January 2007 to April 2015. For analyses, US Active Duty (AD) patients (n=93) were compared to non-AD patients (n=197).

Results:

- The majority of patients were US contractors (47%, n=137), followed by US AD (32%, n=93), reservists (11%, n=33), and US civilian employees (3%, n=10).
- Patients generally spent one day in theater between the initial cardiac complaint and evacuation.
- The sample was mostly male with an average age of 46±11 years old (age range 22 to 79 years) and an average BMI of 29±5; 62% of cardiac patients were either overweight (BMI 25-29.9) or obese (BMI ≥ 30).
- Non-AD patients were more likely to be obese and have a history of hypercholesterolemia.
- Over half of all patients had a history of prior cardiac problems, one in four patients had a history of tobacco use and hypertension, and one in five had a family history of cardiovascular disease (CVD).
- The most common cardiac diagnoses were ST Elevation Myocardial Infarction (STEMI) (29%), Non-ST Elevation Myocardial Infarction (NSTEMI) (20%), and angina (14%); Non-AD patients were more likely to be diagnosed with STEMI (35%).

- Non-AD patients had lower pre-flight oxygen saturation and higher pre-flight oxygen flow rates compared to US AD patients.
- Most patients (81%, n=236) experienced at least one cardiac event in flight; these events included abnormal or a 20% change in HR (62%, n=181), abnormal or a 20% change in MAP (29%, n=83), abnormal or a 20% change in SBP (24%, n=71), complaints of chest pain (14%, n=42), and premature ventricular contractions (5%, n=15).
- Obesity, non-AD status, and family history of CVD were all significant predictors of having an MI in theater, whereas older age, US AD status, and history of previous MI were significantly associated with angina in theater.
- Almost all patients had documentation of receiving the standard medical treatment as outlined in the American Heart Association Criteria for STEMI and NSTEMI management.

Conclusions: Critically ill cardiac patients make up a significant portion of patients transported out of the combat theater. These patients are older, overweight, and have identified risk factors for cardiac morbidity. More strenuous pre-deployment screening for risk factors and prevention strategies could minimize the use of military resources to evacuate these patients from the combat theater.

Evidence Based Recommendations:

- Military planners should anticipate patients with cardiac diagnoses will make up a significant proportion of both critical and non-critical medical evacuations and plan accordingly.
- Prescreening of personnel (to include contractors) for cardiac risk/conditions may decrease CCATT evacuation requirements.
- CCATT training should include the management of patients with critical cardiac illnesses.
- In environments where rapid aeromedical evacuation is not available, medical personnel should have sufficient training and equipment to treat cardiac conditions.
- Since in-theater military treatment facilities do not have access to cardiac catheterization, processes should be in place to identify potential civilian facilities to provide this treatment option.
- Consider continued deployment of cardiologists in the theater of operations. During OEF, deployment of a cardiologist allowed for risk stratification of chest pain (n=1,495), resulting in an 85% return to duty rate and 15% evacuation rate.
    - Watts JA et al. Cardiovascular complaints among military members during operation enduring freedom. US Army Med Dep J. 2016 Apr-Sep;(2-16):148-152.

Savell SC, Arana AA, Medellin KL, Bebarta VS, Perez CA, Reeves LK, Mora AG, Maddry JK. Descriptive analysis of cardiac patients transported by critical care air transport teams. Mil Med. Under review.

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AD	Active Duty
ANOVA	Analysis of Variance
BMI	Body Mass Index
CaCl	Calcium Chloride
CCATT	Critical Care Air Transport Team
CPG	Clinical Practice Guidelines
CVD	Cardiovascular Disease
DNBI	Disease & Non-Battle Injury
FiO_2	Fraction of Inspired Oxygen
HR	Heart Rate
IV	Intravenous
KCl	Potassium Chloride
LRMC	Landstuhl Regional Medical Center
MAP	Mean Arterial Pressure
Mg	Magnesium
MI	Myocardial Infarction
NSTEMI	Non ST Elevation Myocardial Infarction
O_2	Oxygen
OEF	Operation Enduring Freedom
PPI	Proton Pump Inhibitor
SBP	Systolic Blood Pressure
SpO_2	Peripheral Capillary Oxygen Saturation
STEMI	ST Elevation Myocardial Infarction
VS	Vital Signs